



UNIVERSITI PUTRA MALAYSIA

REAL TIME FACE-TRACKING AND IRIS LOCALIZATION

HUSNIZA BINTI RAZALLI
FSKTM 2009 9

REAL TIME FACE-TRACKING AND IRIS LOCALIZATION

By

HUSNIZA BINTI RAZALLI

**Thesis submitted to the school of Graduate Studies, Universiti Putra Malaysia, in
Fulfillment of Requirement for the Degree of Master of Science**

Nov 2009



DEDICATION

I want to dedicate this thesis to my dearest family, especially my beloved husband, Mr. Shah Rizan Mahad, My parent, Mr Razalli Abu Bakar and Mrs. Selmiah Hussin and My Siblings for their care, patient and love throughout my studies.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

REAL TIME FACE-TRACKING AND IRIS LOCALIZATION

By

HUSNIZA BINTI RAZALLI

Nov 2009

Chairman: Rahmita Wirza O. K. Rahmat, PhD

Faculty: Computer Science and Information Technology

Robust, non-intrusive human eye detection problem has been a fundamental and challenging problem for computer vision area. Not only it is a problem of its own, it can be used to ease the problem of finding the locations of other facial features for recognition tasks and human-computer interaction purposes as well. Many previous works have the capability of determining the locations of the human eyes but the main task in this thesis is not only a vision system with eye detection capability. Our aim is to design a real-time, robust, scale-invariant face tracker system with human eye movement indication property using the movements of iris based on localization technique indicate from image processing and circle fitting technique. As a result, our eye tracker system was successfully implemented using non-intrusive webcam with less error.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGESANAN MUKA DAN PENENTUAN LOKASI ANAK MATA DI MASA SEBENAR

Oleh

HUSNIZA BINTI RAZALLI

Nov 2009

Chairman: Rahmita Wirza O. K. Rahmat, PhD

Faculty: Sains Komputer dan Teknologi maklumat

Masalah sistem pengesanan mata yang terperinci tanpa sebarang gangguan adalah satu isu yang penting dan mencabar di dalam visi bidang perkomputeran. Masalah ini bukan hanya mengurangkan masalah dalam carian ciri-ciri paras rupa untuk proses pengecaman tetapi juga boleh digunakan untuk memudahkan tugas pengenalanpastian dan interaksi antara manusia dan sistem komputer. Walaupun kebanyakan hasil kerja terdahulu telah pun mempunyai keupayaan menentukan lokasi mata manusia tetapi tugas utama rencana ini adalah bukan tertumpu kepada pengesanan mata sahaja. Objektif kami adalah untuk merekabentuk sebuah sistem masa sebenar dan terperinci iaitu sistem pengesanan muka berskala dengan ciri-ciri indikasi pergerakan mata berdasarkan pergerakan anak mata (iris) dengan menggunakan teknik penempatan indikasi daripada teknik pemprosesan imej dan penyesuaian bulatan. Hasil daripada kajian ini sistem pengesanan mata ini telah pun berjaya diimplimentasikan menggunakan kamera web dengan ralat yang minima.

Acknowledgements

I would like to gratefully thank my supervisor PM Dr. Rahmita Wirza O.K. Rahmat for her advice and suggestions. I would also like to thank my Co-supervisor PM. Dr Ramlan Mahmud for his advice, and criticism. Not to forget my superior Prof. Dr. Hamid Abdul Rashid for his guidance and caring.

I have to thank my family for their unconditional loving and support. It has been difficult for them to understand the details of what I have been doing and why I have been away from home for so long.

Last, but certainly not least, I would like to thank all the staff of the Faculty of Computer Science and Information Technology of Universiti Putra Malaysia for their services and making my time pleasant one.

With that, best wishes and good health to all, sincerely from me, and thank you once again.

I certify that a Thesis Examination Committee has met on 23 November 2009 to conduct the final examination of Husniza Binti Razalli on her thesis entitled "Real Time Face-Tracking and Iris Localization" in accordance with the Universities and University Colleges Act 1971, and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Md Nasir Sulaiman, PhD

Associate Professor
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Chairman)

Muhammad Taufik Abdullah, PhD

Lecturer
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Internal Examiner)

Shyamala a/p Doraisamy, PhD

Lecturer
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Internal Examiner)

Siti Mariyam Hj Shamsuddin, PhD

Associate Professor
Faculty of Computer Science and Information System
Universiti Teknologi Malaysia
(External Examiner)



BUJANG BIN KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 15 January 2010

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Rahmita Wirza O. K. Rahmat, PhD

Associate Professor
Faculty of Computer science and Information Technology
Universiti Putra Malaysia
(Chairman)

Ramlan Mahmod, PhD

Associate Professor
Faculty of Computer science and Information Technology
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD

Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

HUSNIZA BINTI RAZALLI

Date:

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	iv
ACKNOWLEDGEMENTS	v
APPROVAL	vi
DECLARATION	vii
LIST OF TABLES	xiii
LIST OF FIGURES	xiv
LIST OF ABBREVIATIONS	xvii

CHAPTER

Chapter 1 INTRODUCTION	1
1.1 Research Background	1
1.2 Problem Statement	3
1.3 Research Objective	4
1.4 Research Scope and Limitation	4
1.5 Contributions of Research	5
1.6 Research Methodology	6
1.6.1 Problem Identification	6
1.6.2 Data Requirements	6
1.6.3 System Design	7
1.6.4 Coding and Implementation	7
1.7 Organization of the Thesis	7
Chapter 2 LITERATURE REVIEW	10
2.1 Motivation	10
2.2 Structure of Human Eye	10
2.3 Related Works	14
2.3.1 Face Detection in Computer Vision Area	16

2.3.1.1	Knowledge-Based Methods	18
2.3.1.2	Feature-Invariant Approaches	20
2.3.1.3	Template Matching Methods	21
2.3.1.4	Appearance-Based Methods	22
2.3.2	Eye Detection and Localization in Computer Vision Area	25
2.3.2.1	IR Based Approaches	27
2.3.2.2	Image Based Approaches	27
2.3.3	Conclusions from the Literature Survey	28
2.4	Some Necessary Preliminaries	29
2.4.1	Skin Color Segmentation	29
2.4.1.1	Color Space	30
2.4.2	Hough Transform Algorithm	36
2.4.2.1	Advantage and Disadvantage of Hough transform	38
2.4.2.2	Classical Representations of Hough Straight Line Transform	39
2.5	Chapter Summary	40
Chapter 3	METHODOLOGY	42
3.1	Introduction	42
3.2	Research Design	42
3.3	Face Region Extraction Technique	44
3.3.1	Using HS Space Skin Color Segmentation	44
3.3.2	Morphological Operation	55
3.3.3	8-Connected Component Labeling	56
3.4	Eye Region Extraction and Iris Localization Technique	59
3.4.1	Eye Region Determination Technique	59
3.4.1.1	Cropping Function	62
3.4.2	Iris Localization	63
3.4.2.1	Thresholding	63
3.4.2.2	Iris Edge Contour Detection	64
3.4.2.3	Hough Circle Transformation	65
3.4.2.4	Circle Fitting Process	70
3.5	Chapter Summary	73

Chapter 4 ANALYSIS AND DISCUSSION OF THE RESULT	74
4.1 Introduction	74
4.2 Data Preparation	74
4.2.1 Face Detection	75
4.2.2 Eye Detection	76
4.2.3 Iris Localization	77
4.3 Properties of Overall Test Setup	78
4.4 Properties of Face Detection Test Setup	79
4.5 Performance of the Face Tracker	81
4.5.1 Tracking in the Presence of the Multiple Background and Lighting Sources	81
4.5.2 Tracking in Variable Skin Color	83
4.6 Properties of Eye Detection and Iris Localization Test Setup	84
4.7 Performance of the Eye Detection and Iris Localization	85
4.8 Properties of Real-Time System Test Setup	86
4.9 Performance of the Real-Time System	86
4.10 Chapter Summary	88
 Chapter 5 REAL-TIME FACE TRACKING AND IRIS LOCALIZATION APPLICATIONS	 90
5.1 Introduction	90
5.2 Application Component	90
5.3 Application Capabilities	92
5.4 Real-Time Application	92
5.4.1 The Design of Real-Time System	93
5.4.2 System Framework	93
5.4.3 Video Processing	97
5.4.4 Converting Video to Images	98
5.4.5 Tracking Process	98
5.4.6 Summary of Real-Time Application	101
5.5 Chapter Summary	101
 Chapter 6 CONCLUSION AND FUTURE WORK	 103
6.1 Introduction	103

6.2	Conclusion of the Research	103
6.3	Limitations and Future Work	104
6.4	Application Areas	104
6.5	Summary	106
BIBLIOGRAPHY		107
BIODATA OF THE AUTHOR		110

LIST OF TABLES

Table		Page
4.1	Experimental Result of Tracking in the Presence of the Multiple Background and Lighting Sources	82
4.2	Experimental Result of Tracking in Variable Skin Color	83
4.3	Experimental Result of Performance of Eye Detection and Iris Localization	85
4.4	Frame Error Rate Result	88
4.5	Iris Localization Result	88

LIST OF FIGURES

Figure	Page
2.1 Frontal View of Human Eye	111
2.2 A typical face used in knowledge-based top-down method (G. Yang and T. S. Huang, 1994).	19
2.3 Hidden Markov Model for face localization. a) Observation vectors, b)Hidden states (F. S. Samaria, 1994)	25
2.4 Visualization of RGB color model.	32
2.5 Visualization of RGB color space.	32
2.6 Visualization of HSV color model.	35
2.7 Visualization of HSV color space	35
2.8 RGB dimensions are converted into HSV.	36
3.1 Research Methodology	43
3.2 Face skin colors collected from 56 persons.	47
3.3 HSV color space converted image.	48
3.4 Face skin color projected in 2D <i>HS</i> color space.	49
3.5 Face skin color projected in 3D <i>HS</i> color space.	49
3.6 A single-faced image.	51
3.7 The segmented single-faced image.	51
3.8 A single-faced image with cluttered background.	52
3.9 The segmented single-faced image with cluttered background.	52
3.10 A multiple-person image as input image.	53
3.11 A segmented multiple-person image as input image.	53
3.12 A multiple-faced image as input image.	54

3.13	The segmented multiple-faced image.	54
3.14	Illustration of Morphological Open Operation	56
3.15	Illustration of Morphological Process to the dedicated image	58
3.16	Left and Right Eyes Region from Devoted Face Image	60
3.17	The face model used in eye detection	61
3.18	Search Areas for Left and Right Eyes	61
3.19	Algorithm for Eye Region Extraction	62
3.20	Illustration of Thresholding Process	64
3.21	Each point in geometric space (left) generates a circle in parameter space (right). The circles in parameter space intersect at the (a, b) that is the center in geometric space.	67
3.22	Extracted Iris Edge Points from Input Image	69
3.23	Iris Edge Points	72
3.24	Circle Fitting Process to the Targeted Points	72
4.1	Face Detection Results	946
4.2	Eyes database produced from cropping function	96
4.3	Fitted circle to the eye database	100
4.4	Face Detection Results with Caltech Database Process	82
4.5	Face Detection Results with Essex Face Database	84
4.6	Logitech® Quickcam web camera	86
4.7	Face Detection and iris localization results for an unknown person	87
5.1	Structure of the complete system	91
5.2	Overall process flow of the proposed system	94
5.3	Process flow of Real-time Application	96
5.4	Flowchart of the Tracking Process	100

LIST OF ABBREVIATIONS

ASL	Applied Science Laboratories
HCI	Human Computer Interaction
HMM	Hidden Markov Model
HS-Space	Hue, Saturation Space
HSV	Hue, Saturation and Value
IR	Infrared
NIR	Near Infrared
RGB	Red, Green and Blue
YCbCr	Luminance Chrominance
PAL	Phase Alternating Line
NTSC	National Television System Committee
ROI	Region of Interest
TM	Telekom Malaysia
WWW	World Wide Web

CHAPTER 1

INTRODUCTION

1.1 Research Background

Face tracking and iris localization using computer vision techniques have the potential to become an important component in future perceptual user interfaces. So by this motivation designing a real-time face tracking and iris localization software compatible with a standard PC environment is the main aim of this research.

In general, the term “*face detection*” is widely used when static face images are of concern and the main aim is to find the face region which contains both eyes, and “*face tracking*” term is used referring to the process of continuously detecting face region in video sequences which contains only unconstrained images. And “*iris localization*” is the process to extract the position of the circular iris in eye region images (Z. Savas, 2005). In this research the term “*face tracking and iris localization*” means real-time, continuous detection of human face individually and extraction the position of the iris features with scale invariance property and without making the assumption that the image sequences contain only face images. And “*Real-time face tracking and iris localization*” means detect the human face and localize the position of the iris features in a real time environment, where there is

a continual input, process and output of data and the data has to be processed in a small stipulated time period (real time).

The most accurate, but least user-friendly technology uses physical attachment to the front of the eye. A non-slipping contact lens is ground to fit precisely over the corneal bulge. Another popular common technology is based on non-contacting, special equipment aided vision techniques such as illuminating the eye with a barely-visible infrared light source. These methods are obviously practical only for laboratory studies, as they are very awkward, uncomfortable for practical approaches. In this thesis a more practical real-time approach for simultaneously tracking and iris feature extraction of individual eyes is implemented using a web camera based vision technique without using the special equipment given above.

The eye tracker sits in a several meters range to the camera and head motion is restricted only to the extent necessary to keep the face, eye region and pupil of eye within view of the camera. The eye tracker provides data about the location of the face and iris of the eye. The x and y coordinates data of both eyeball areas, outline of the eye area and the position of the iris are detected using image processing techniques.

The developed technique is aimed to be a fast and easy to operate real-time method although work with image processing method, thus, suitable for ordinary user settings outside the laboratory environment although it is not thought to be as accurate as equipment based techniques given above.

1.2 Problem Statement

Human face image analysis, detection and recognition have become some of the most important research topics in the field of computer vision and pattern classification. The potential applications involve topics such as face detection, face identification and recognition, and facial expression analysis. Among these research topics, one fundamental but very important problem to be solved is automatic eye detection. The eye is the most significant and important feature in a human face, as extraction of the eyes are often easier as compared to other facial features. Eye detection is also used in person identification by iris matching. Only those image regions that contain possible eye pairs will be fed into a subsequent face verification system. Localization of eyes is also a necessary step for many face classification methods. For comparing two faces, the faces must be aligned. As both the locations of eyes and the inter-ocular distance between them are relatively constant for most people, the eyes are often used for face image normalization (T. Rajpathak, R. Kumar, E. Schwartz, 2009).

Based on understanding of the previous research, following are identified problems that exist in this research:

- i) Difficulties to identify criteria of automatic face detection method in cluttered background images.
- ii) Difficulties to process a framework related on the eye detection an iris localization method with low resolution image.
- iii) Complexity to have a suitable real-time system for face tracking and iris localization with collaborations of both detections.

In this research, identification of face tracking and iris localization techniques derived from automatic face detection process in cluttered background images are examined. Therefore, a real-time tracking system will be able to develop for automatic localize the position of the iris and automatic detect face area from cluttered background images, just only using non-intrusive web camera and also work with low resolution images.

1.3 Research Objective

The objective of this research is to design and implement a real-time face tracking and iris localization program based on combination of;

- Face detection in complex background images using feature invariant approach for skin color segmentation based on HS-space skin color segmentation.
- Iris localization based on circular hough transform method for edge points detection in normal illumination

1.4 Research Scope and Limitation

Upon the successfully of face region detection, there is some limitation that we need to consider in order to obtained a better detection result. This research work is based on image processing technique and focused on detection of the face region in cluttered background images. The images capture using normal web camera with

320×240 resolutions; consequently the extraction of eye region and iris localization of was made from the same data. We assume that the persons that we use as a sample wearing a different color hair scarf with their skin. The samples also consist of the person who did not wearing spectacles. And we as well suppose that the sample's face region is in the view of the camera.

1.5 Contributions of Research

We can split the contributions of this research into three parts:

i. Tracking algorithm

A new framework is designed which provides flexibility to users to detect face region in cluttered image and track the movement of the human eye accordingly.

ii. Iris localization

We localize the position of the iris using Hough circle algorithm instead of projection function.

iii. Real-time Application

A new real-time eye tracking and iris localization system proposed based on the properties of the eye.

1.6 Research Methodology

In carrying out this research, we need to have a methodology used in order to ensure that the research will be done successfully. The detailed information about the methodology part is stated in chapter 3.

1.6.1 Problem Identification

We started this research with identifying the problem by doing some literature reviews on the related matter. Since this research is about tracking and detection of human face and eye in real-time environment, therefore the study focused on understanding techniques done by previous researchers in generating them. Based on the review made, we chose a technique that resembles the closest to what we are proposing to do to be used as the guideline.

1.6.2 Data Requirements

The next step involves capturing data to recognize the face and eye region, after that calculate and obtain the position of the iris during the movement of the eye. This can be acquired through a web camera. For our purposed, we used normal web camera with 320x240 resolutions.

1.6.3 System Design

Based on the requirements and the detailed analysis, the conceptual framework of real-time eye tracking and iris localization system is designed based on our proposed objective. In this phase, the flow of the program is clearly defined. Contributions made for this research are stated as well, which consist of three major parts, namely the face detection algorithm, localization technique and also the real-time eye tracking and iris localization.

1.6.4 Coding and Implementation

After designing the new framework, the whole framework system is required to be converted into computer understanding language. It is an important stage where the defined procedures are transformed into control specifications by the help of a computer language.

1.7 Organization of the Thesis

The thesis is organized in accordance with the standard structure of the thesis and dissertations at Universiti Putra Malaysia. The thesis has seven chapters, including the introductory chapter that covers the background information that leads to an idea of furthering in detail the concepts of face tracking and iris localization problem.